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(54) **PIPE LINING SYSTEM AND METHOD**

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B28C 7/10	(2006.01)
B28C 9/04	(2006.01)
B05D 7/22	(2006.01)

(52) **U.S. Cl.**

CPC ***B28B 19/0023*** (2013.01); ***B05D 7/225*** (2013.01); ***B28C 7/10*** (2013.01); ***B28C 7/162*** (2013.01); ***B28C 9/0472*** (2013.01); ***E04G 21/00*** (2013.01); ***E21D 11/00*** (2013.01); *B05D 2254/04* (2013.01)

(58) **Field of Classification Search**

CPC F16L 55/1645; F16L 55/32; F16L 55/18; F16L 55/164; F16L 2101/16; B28B 19/0023; B05B 13/0636; B05C 7/02; Y10S 118/10; E21D 11/00; E04G 21/00; B28C 7/162; B28C 7/10; B28C 9/0472

USPC 118/306

See application file for complete search history.

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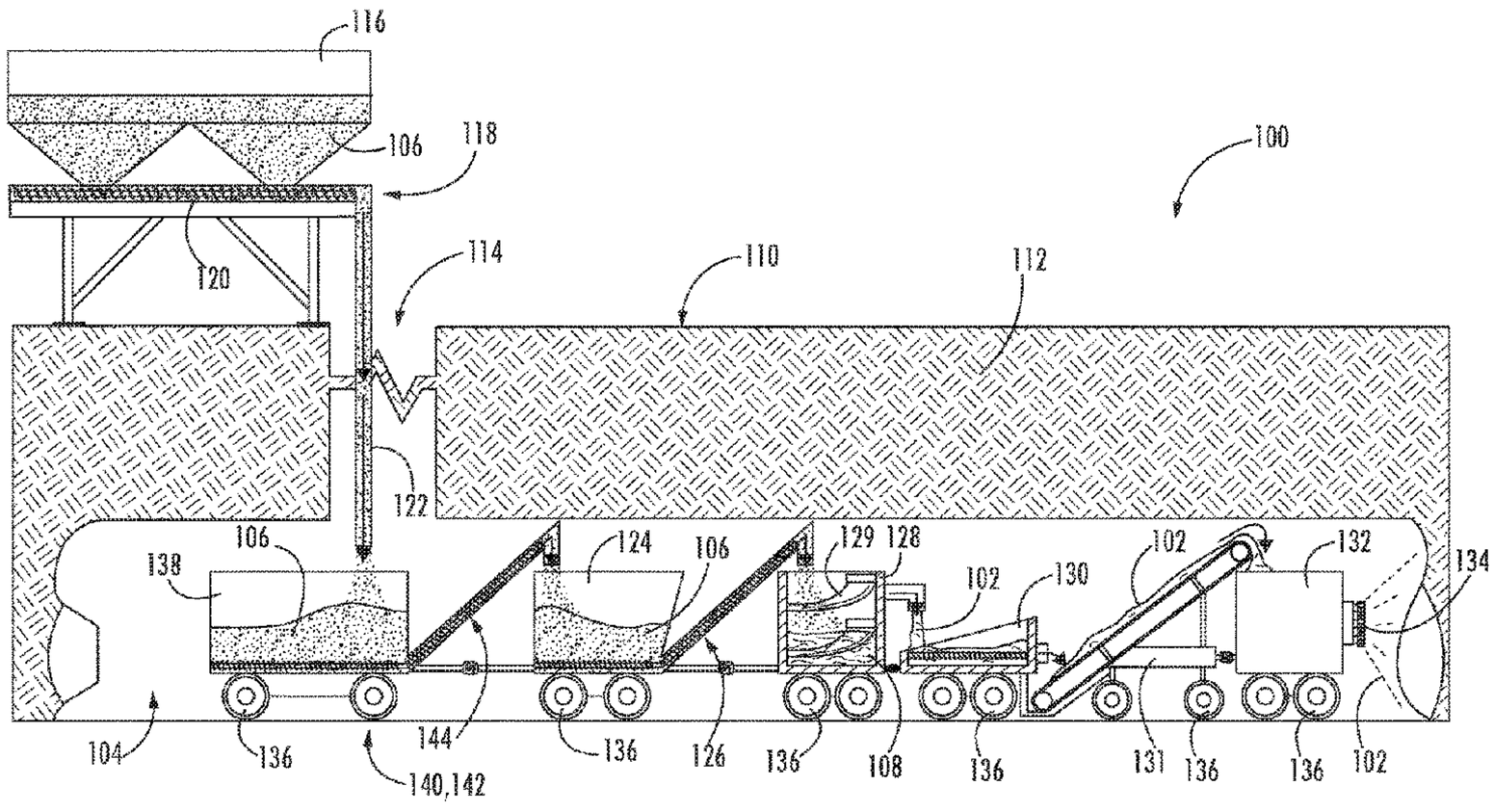
(57) **ABSTRACT**

A method of lining a pipe with a lining mixture formed from a dry component and a liquid is discussed. The method includes placing the dry component in a dry component surface container located above ground, conveying the dry component from the dry component surface container to a dry component subterranean supply container located underground, conveying the dry component from the dry component subterranean supply container to a mixer located underground, mixing the dry component with the liquid to form the lining mixture, and applying the lining mixture to the pipe with a mixture applicator.

13 Claims, 4 Drawing Sheets



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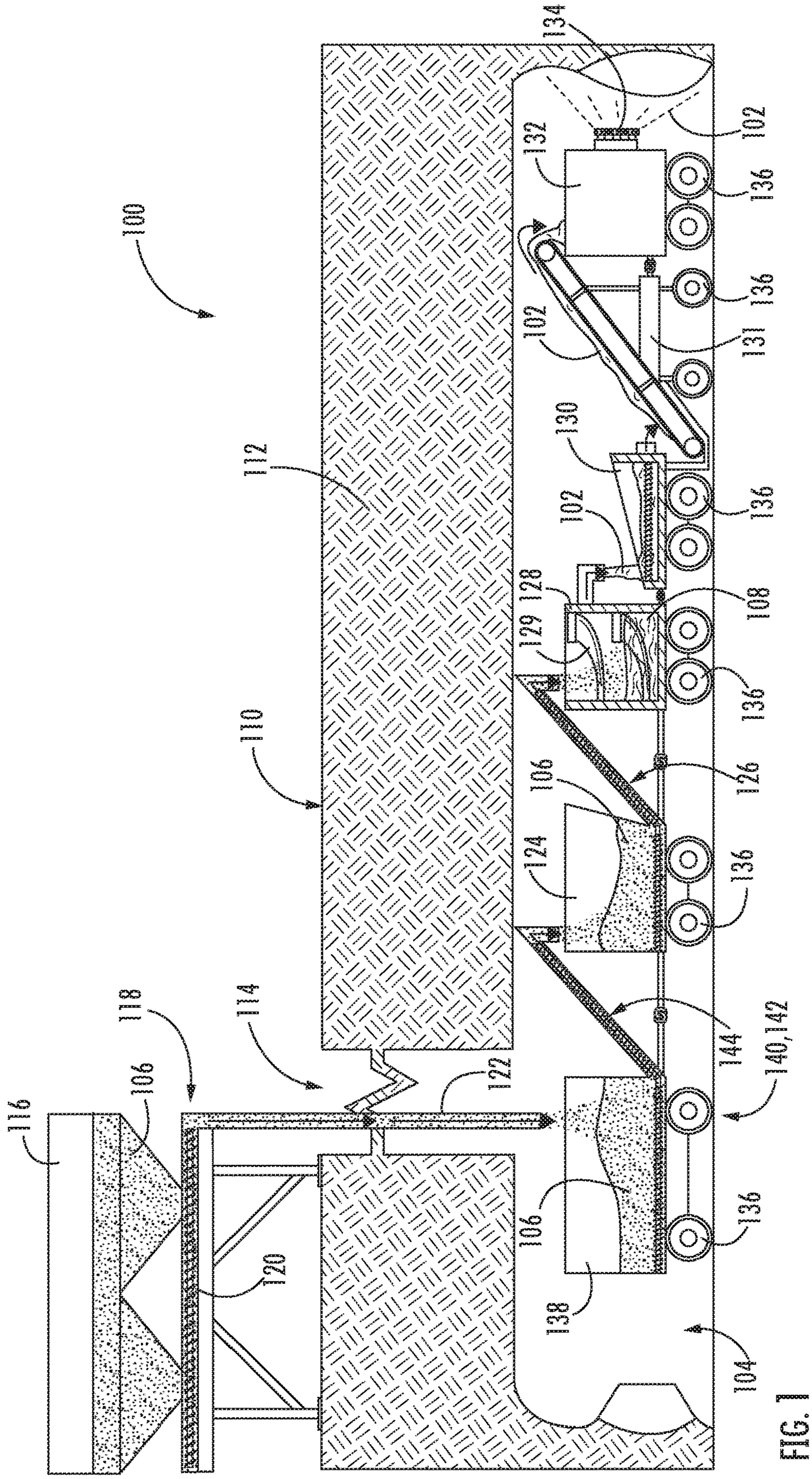
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FIG. 1

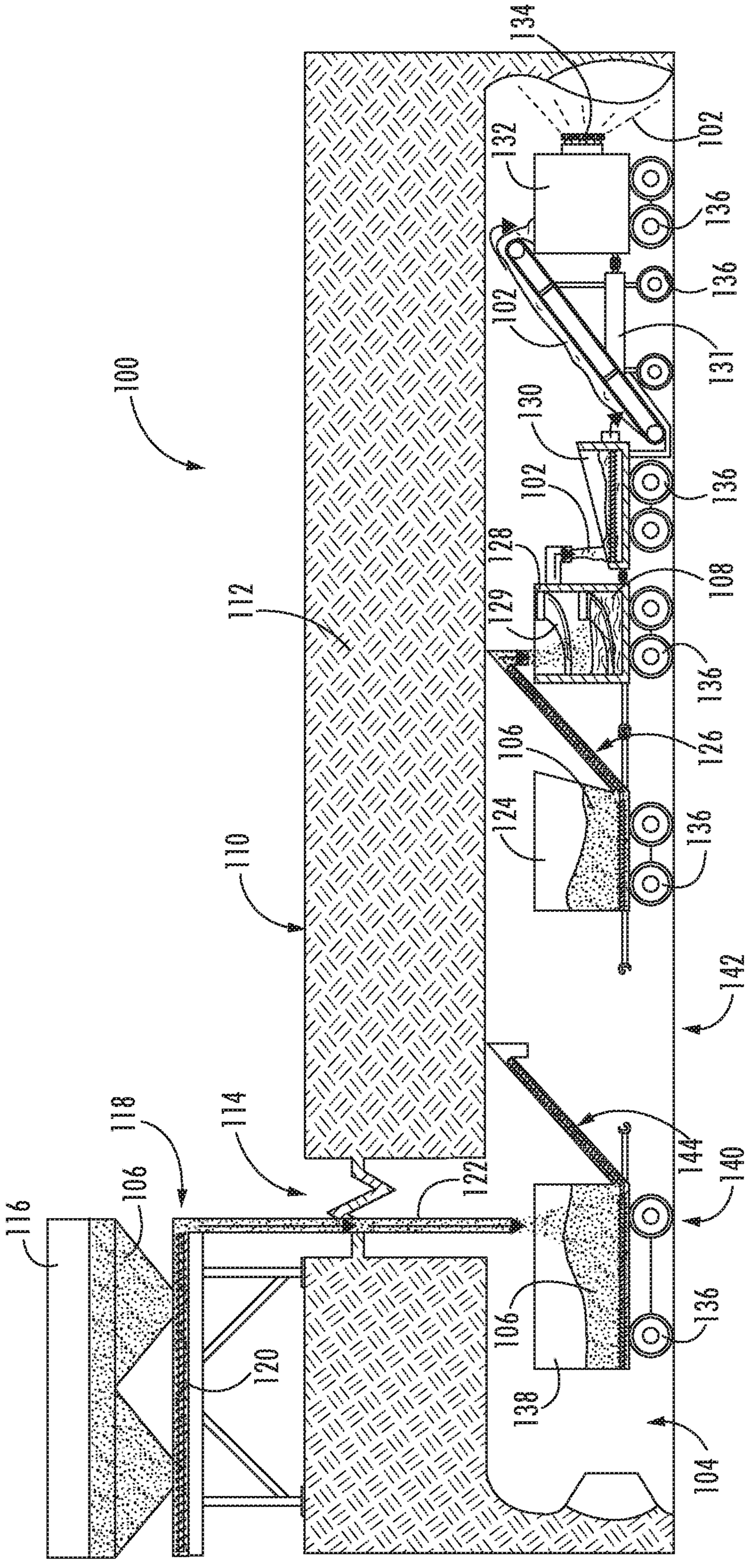
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FIG. 2

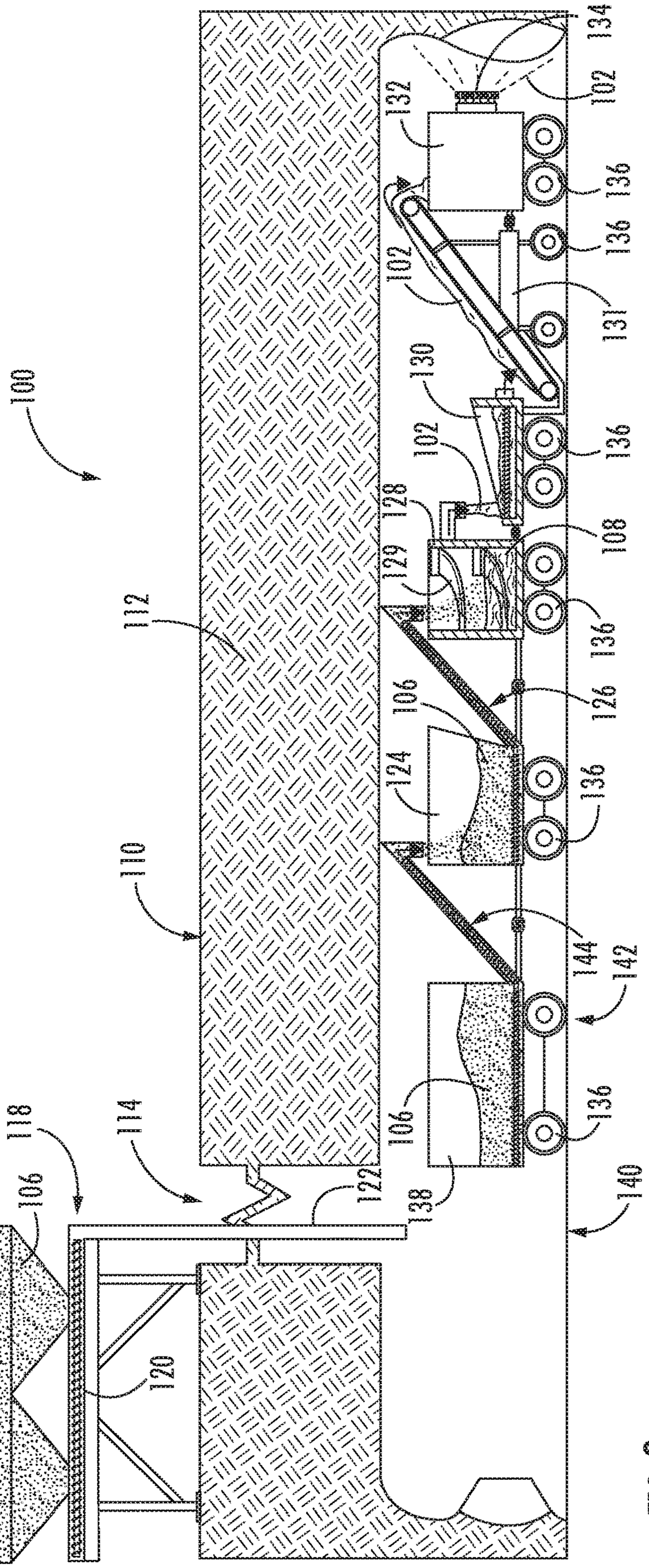
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FIG. 3

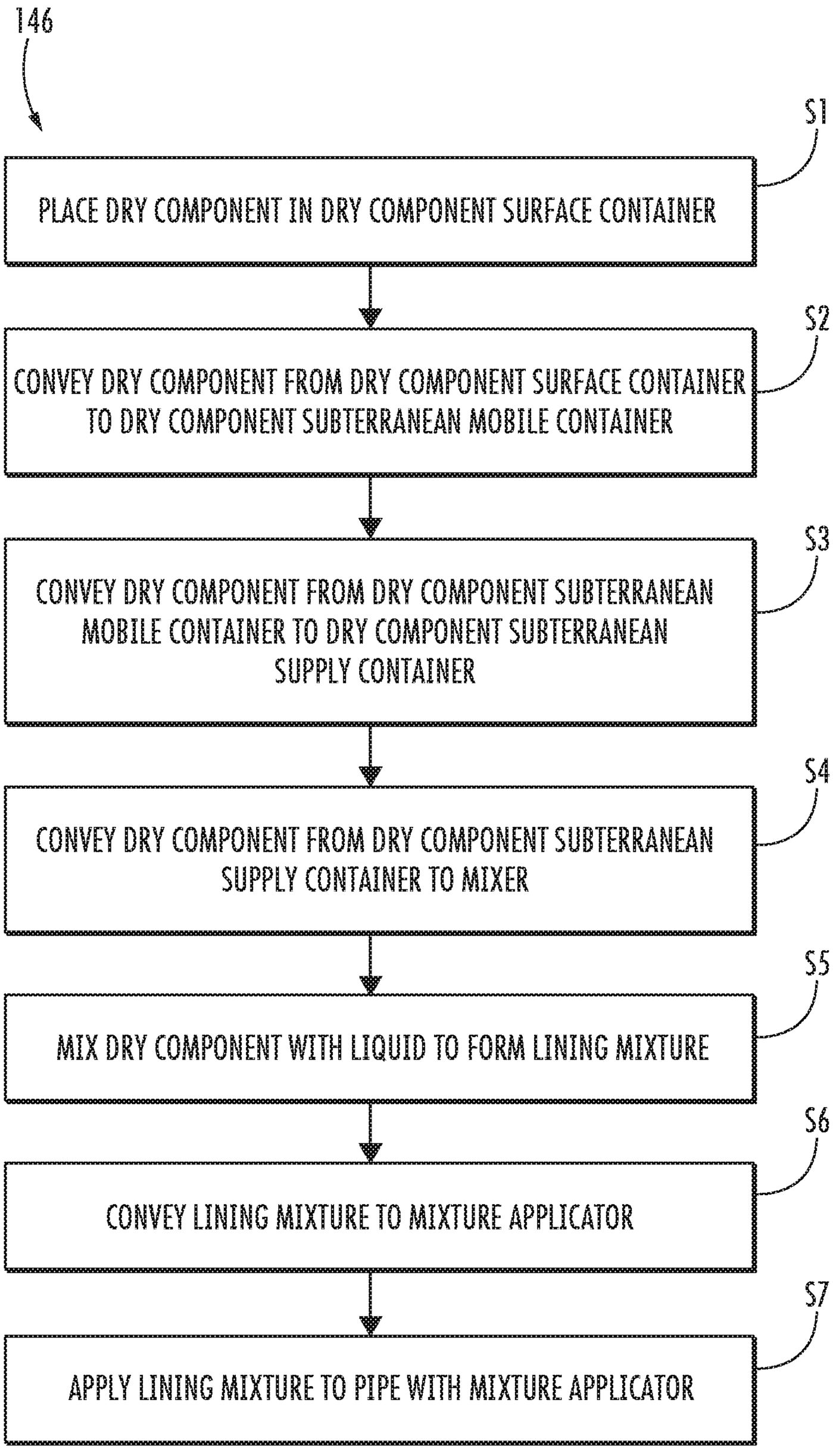
146
S1
PLACE DRY COMPONENT IN DRY COMPONENT SURFACE CONTAINER
S2
CONVEY DRY COMPONENT FROM DRY COMPONENT SURFACE CONTAINER TO DRY COMPONENT SUBTERRANEAN MOBILE CONTAINER
S3
CONVEY DRY COMPONENT FROM DRY COMPONENT SUBTERRANEAN MOBILE CONTAINER TO DRY COMPONENT SUBTERRANEAN SUPPLY CONTAINER
S4
CONVEY DRY COMPONENT FROM DRY COMPONENT SUBTERRANEAN SUPPLY CONTAINER TO MIXER
S5
MIX DRY COMPONENT WITH LIQUID TO FORM LINING MIXTURE
S6
CONVEY LINING MIXTURE TO MIXTURE APPLICATOR
S7
APPLY LINING MIXTURE TO PIPE WITH MIXTURE APPLICATOR

FIG. 4

PIPE LINING SYSTEM AND METHOD

BACKGROUND

The present disclosure relates to a system and method for lining an interior surface of a pipe.

SUMMARY

In one embodiment, the disclosure provides a method of lining a pipe with a lining mixture formed from a dry component and a liquid. The method includes placing the dry component in a dry component surface container located above ground, conveying the dry component from the dry component surface container to a dry component subterranean supply container located underground, conveying the dry component from the dry component subterranean supply container to a mixer located underground, mixing the dry component with the liquid to form the lining mixture, and applying the lining mixture to the pipe with a mixture applicator.

In another embodiment, the disclosure provides a pipe lining system using a lining mixture formed from a dry component and a liquid to line a pipe. The pipe lining system includes a dry component surface container. A surface container conveyor assembly is associated with the dry component surface container. A dry component subterranean supply container is downstream from the surface container conveyor assembly. A supply container conveyor assembly is associated with the dry component subterranean supply container. A mixer is downstream from the supply container conveyor assembly. The mixer mixes the liquid with the dry component to form the lining mixture. A mixture applicator is downstream from the mixer. The mixture applicator applies the lining mixture to the pipe.

Other aspects of the disclosure will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a schematic cross-sectional side elevation view of an embodiment of the pipe lining system.

FIG. **2** illustrates the pipe lining system of FIG. **1** with the mixer and mixture applicator further along in a pipe while the mobile container receives the dry component.

FIG. **3** illustrates the pipe lining system of FIG. **1** with the mobile container moved to a loading position to convey the dry material to the supply container.

FIG. **4** illustrates an example flow diagram relating to an embodiment of the method of lining a pipe.

DETAILED DESCRIPTION

Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways.

Turning now to FIG. **1**, a pipe lining system **100** embodying the present invention is shown. The pipe lining system **100** is used to apply a lining mixture **102** to an interior surface of a pipe **104**. The lining mixture **102** is formed from a dry component **106**, such as a mortar or cement mix powder, and a liquid **108**, such as water. The pipe **104** is

located underground below a surface **110** of the ground matrix **112**. At least one vertical passage **114** allows access to the pipe **104** from above ground.

The pipe lining system **100** includes a dry component surface container **116**. The dry component surface container **116** may be of any appropriate shape and size, but particular embodiments include a relatively high-capacity container. The dry component surface container **116** rests either directly or indirectly on the ground surface **110**. In practice, such a container may be filled with material in bulk utilizing, for instance, construction equipment running along the ground surface **110**. In the illustrated embodiment, the dry component surface container **116** is an open-top hopper.

Also shown in FIG. **1**, the dry component surface container **116** of the illustrated embodiment includes a surface container conveyor assembly **118**. In the illustrated embodiment, the surface container conveyor assembly **118** includes a generally lateral conveyance section **120** and a generally vertical conveyance section **122**. The generally lateral conveyance section **120** and the generally vertical conveyance section **122** cooperatively convey the dry component **106** from the dry component surface container **116** above the ground surface **110** to the interior of the pipe **104** via the vertical passage **114** defined in the ground matrix **112**. In the illustrated embodiment, the generally lateral conveyance section **120** includes a screw conveyor, and the generally vertical conveyance section **122** includes a generally vertical pipe.

With continued reference to FIG. **1**, the illustrated embodiment includes a dry component subterranean supply container **124** located underground and downstream from the surface container conveyor assembly **118**. Particularly, the dry component subterranean supply container **124** is located within the pipe **104**. The dry component subterranean supply container **124** may be of any appropriate size and shape, but particular embodiments include a relatively low-capacity container when compared to the dry component surface container **116**. The dry component subterranean supply container **124** may receive the dry component **106** either directly or indirectly from the surface container conveyor assembly **118**. In the illustrated embodiment, the dry component subterranean supply container **124** is an open-top hopper. The dry component subterranean supply container **124** of the illustrated embodiment includes a supply container conveyor assembly **126**. In the illustrated embodiment, the supply container conveyor assembly **126** includes a screw conveyor.

As shown in FIG. **1**, a mixer **128** is located downstream from the supply container conveyor assembly **126**. The mixer **128** receives the dry component **106** from the supply container conveyor assembly **126** and mixes the liquid **108** with the dry component **106** to form the lining mixture **102**. An example of a mixer **128** includes one or more mixing paddles **129** to mix the liquid **108** with the dry component **106** in a manner similar to a concrete mixer. The mixer **128** is illustrated as having an open top to receive the dry component **106**. The liquid **108**, such as water, is supplied from a tank fluidly coupled to the mixer **128**. This tank (not shown) can be mounted to the mixer **128**, or it may be located elsewhere, such as above the ground surface **110**, with one or more lines feeding liquid **108** to the mixer. In some embodiments, the liquid **108** may simply be supplied from a municipal water source to the mixer **128**.

A wet mix conveyor **130** receives the lining mixture **102** from the mixer **128**. The wet mix conveyor **130** is illustrated as having an open-top design with walls extending higher on the downstream end than the upstream end. This angled

design of the illustrated embodiment may aid in containing the lining mixture **102** even if the lining mixture **102** tends to bunch up at the downstream end of the wet mix conveyor **130**. The illustrated embodiment includes a wet mix conveyor **130** having a screw conveyor. The screw conveyor of the wet mix conveyor **130** may serve to move the lining mixture **102** while also further mixing the lining mixture **102** to ensure better incorporation of the dry component **106** and the liquid **108**. The screw conveyor of the wet mix conveyor **130** is shown in a horizontal orientation, but other embodiments may include an inclined screw conveyor.

A belt conveyor **131** receives the lining mixture **102** from the wet mix conveyor **130**. The belt conveyor **131** is illustrated schematically and may include further components such as side containment walls that are angled upwardly and outwardly from the belt of the belt conveyor **131** to aid in containing the lining mixture **102** as it travels along the belt. The belt conveyor **131** moves the lining mixture **102** both horizontally to move farther along the pipe **104** and vertically to elevate the lining mixture **102** so it is high enough to drop into an open top of a downstream mixture applicator **132**. Some embodiments include an inclined screw conveyor instead of the belt conveyor **131**. In such embodiments, the inclined screw conveyor may be separate from the wet mix conveyor **130** or integrated therewith as a single assembly.

The mixture applicator **132** receives the lining mixture **102** from the belt conveyor **131**. The mixture applicator **132** is configured to apply the lining mixture **102** to the interior surface of the pipe **104**. As an example, the illustrated embodiment includes multiple spray nozzles **134** to spray the lining mixture **102** onto the interior surface of the pipe **104**. Other lining mixture application configurations are also contemplated.

The mixture applicator **132** is configured to move through the interior of the pipe **104** to apply the lining mixture **102** along the interior surface of the pipe. In the illustrated embodiment, the belt conveyor **131**, the wet mix conveyor **130**, and the mixer **128** move with the mixture applicator **132**. To facilitate the movement of the mixture applicator **132**, the belt conveyor **131**, the wet mix conveyor **130**, and the mixer **128**, each may include one or more wheels **136**. Of course, other structures facilitating movement of the mixture applicator **132** and the mixer **128** are contemplated such as, for instance, one or more tracks, sleds, bearings, rollers, and the like.

The dry component subterranean supply container **124** also moves along the interior of the pipe **104**. As discussed above with regard to the mixture applicator **132** and the mixer **128**, the dry component subterranean supply container **124** may also include one or more wheels **136**. In the illustrated embodiment, the dry component subterranean supply container **124** moves with the mixer **128**. Particularly, the dry component subterranean supply container is coupled with or connected to the mixer **128**. This connection may be permanent, but this connection could instead be a releasable connection.

Referring to FIGS. **1-3**, the pipe lining system **100** may further include a dry component subterranean mobile container **138** located underground in the interior of the pipe **104**. In the illustrated embodiment, the dry component subterranean mobile container **138** is located downstream from the surface container conveyor assembly **118** and upstream of the dry component subterranean supply container **124**. Dry component **106** leaves the surface container conveyor assembly **118** and is received in the dry component subterranean mobile container **138** at a loading location **140**. After loading with dry component **106**, the dry component subterranean mobile container **138** moves along the interior of the pipe **104** from the loading location **140** to an unloading location **142** adjacent the dry component subterranean supply container **124**. As discussed above with the other components of the pipe lining system **100**, the dry component subterranean mobile container **138** may include one or more wheels **136**. In the illustrated embodiment, the dry component subterranean mobile container **138** is an open-top hopper.

A mobile container conveyor assembly **144** is associated with the dry component subterranean mobile container **138**. The mobile container conveyor assembly **144** includes a screw conveyor in the illustrated embodiment. Also in the illustrated embodiment, the mobile container conveyor assembly **144** is connected to and moves with the dry component subterranean mobile container **138**. The dry component **106** leaves the mobile container conveyor assembly **144** and enters the subterranean supply container **124** when the dry component subterranean mobile container **138** is in the unloading location **142**. The unloading location **142** moves with the dry component subterranean supply container **124** as the dry component subterranean supply container, the mixer **128**, and the mixture applicator **132** move along the interior of the pipe **104**. As such, the dry component subterranean mobile container **138** makes runs back and forth from below the generally vertical conveyance section **122** of the surface container conveyance assembly **118** to the dry component subterranean supply container **124**. In some embodiments, the dry component subterranean mobile container **138** removably connects to the dry component subterranean supply container **124** when the dry component subterranean mobile container **138** is unloading the dry component **106** into the dry component subterranean supply container **124** at the unloading location **142**.

Turning now to FIG. **4**, the present disclosure also relates to a method **146** of lining a pipe **104** with a lining mixture **102** formed from a dry component **106** and a liquid **108**. The illustrated embodiment of the method starts at step S**1**, wherein the dry component **106** is placed in the dry component surface container **116** aboveground, such as on the ground surface **110**. Next, the dry component **106** is conveyed from the dry component surface container **116** to the dry component subterranean mobile container **124**, which is located underground in the interior of the pipe **104**, in a second step S**2**. Then, in a third step S**3**, the dry component **106** is conveyed from the dry component subterranean mobile container **138** to the dry component subterranean supply container **124**. Steps S**2** and S**3** indirectly accomplish a step of conveying the dry component **106** from the dry component surface container **116** to the dry component subterranean supply container **124**. Then, in a fourth step S**4**, the dry component **106** is conveyed from the dry component subterranean supply container **124** to the mixer **128**, which is located underground in the interior of the pipe **104**. The liquid **108** and the dry component **106** are then mixed by the mixer **128** to form the lining mixture **102** in a fifth step S**5**. In a sixth step S**6**, the lining mixture **102** is conveyed to the mixture applicator **132**, being carried by both a wet mix conveyor **130** and a belt conveyor **131**. Finally, in a seventh step S**7**, the lining mixture **102** is applied to the interior surface of the pipe **104** with the mixture applicator **132**.

As shown in FIG. **1**, the mixture applicator **132**, the belt conveyor **131**, the wet mix conveyor **130**, the mixer **128**, and the dry component subterranean supply container **124** may be positioned such that the loading location **140** and the unloading location **142** are the same location. In such a

situation, the dry component subterranean mobile container **138** simply remains stationary while receiving the dry component **106** from the surface container conveyor assembly **118** and also while the mobile container conveyor assembly **144** delivers the dry component to the dry component subterranean supply container **124**.

As shown in FIGS. **2** and **3**, however, the mixture applicator **132**, the belt conveyor **131**, the wet mix conveyor **130**, the mixer **128**, and the dry component subterranean supply container **124** are, more often than not, positioned such that the loading location **140** and the unloading location **142** are separated by some distance along the interior of the pipe **104**. In this situation, the second step S**2** includes the dry component subterranean mobile container **138** receiving the dry component **106** from the surface container conveyor assembly **118**, particularly from the generally vertical conveyance section **122**, while the dry component subterranean mobile container is in the loading location **140**. Next, the third step S**3** includes the dry component subterranean mobile container **138** moving from the loading location **140**, or first underground location, to the unloading location **142**, or second underground location. The third step S**3** also includes delivering the dry component **106** to the dry component subterranean supply container **124** from the dry component subterranean mobile container **138** via the mobile container conveyor assembly **144** while the dry component subterranean mobile container is in the unloading location **142**.

In this described method, the second, third, and fourth steps S**2**, S**3**, S**4** further include conveying the dry component **106** with a respective screw conveyor included as part of each of the surface container conveyor assembly **118**, the mobile container conveyor assembly **144**, and the supply container conveyor assembly **126**. The mobile container conveyor assembly **144** and the supply container conveyor **118** include a first and second inclined screw conveyor, respectively, in some embodiments. Also in this described method, the sixth step S**6** further includes conveying the lining mixture **102** with a respective screw conveyor included as part of the wet mix conveyor **130**.

With regard to the methods contemplated herein, the above discussion of illustrated or example embodiments should not be considered to be limiting. The method steps may be carried out in any appropriate order, and steps may be added or removed as appropriate for a given application.

Although embodiments including the dry component subterranean mobile container **138** have been discussed, the current disclosure also contemplates embodiments without the dry component subterranean mobile container. In such embodiments, the dry component subterranean supply container **124** would make trips back and forth from a location receiving the dry component **106** from the surface container conveyor assembly **118** to a location delivering the dry component to the mixer **128**.

In addition to the example embodiments discussed explicitly herein, the current disclosure contemplates other embodiments having additional or alternative features or configurations. Indeed, features from one embodiment may be added to or may replace features of another embodiment to form still another embodiment. As such, the discussion above should be viewed as exemplary in nature and not as a limit on the following claims. Various features and advantages of the disclosure are set forth in the following claims.

What is claimed is:

1. A pipe lining system using a lining mixture formed from a dry component and a liquid to line a pipe, the pipe lining system comprising:

a dry component surface container;

a surface container conveyor assembly associated with the dry component surface container;

a dry component subterranean supply container downstream from the surface container conveyor assembly;

a supply container conveyor assembly associated with the dry component subterranean supply container;

a mixer downstream from the supply container conveyor assembly, the mixer configured to mix the liquid with the dry component to form the lining mixture;

a mixture applicator downstream from the mixer, the mixture applicator configured to apply the lining mixture to the pipe,

a dry component subterranean mobile container downstream from the surface container conveyor assembly and upstream from the dry component subterranean supply container,

wherein the dry component subterranean mobile container is movable relative to the dry component subterranean supply container from a loading location to an unloading location;

wherein, at the loading location, the dry component subterranean mobile container is positioned to receive the dry component from the surface container conveyor assembly; and

wherein, at the unloading location, the dry component subterranean mobile container is positioned to deliver the dry component to the dry component subterranean supply container.

2. The pipe lining system of claim **1**, further comprising

a mobile container conveyor assembly associated with the dry component subterranean mobile container to deliver the dry component to the dry component subterranean supply container.

3. The pipe lining system of claim **2**, wherein the mobile container conveyor assembly is connected to the dry component subterranean mobile container and moves with the dry component subterranean mobile container.

4. The pipe lining system of claim **1**, wherein

the dry component subterranean supply container moves with the mixer; and

the unloading location is associated with the dry component subterranean supply container and moves with the dry component subterranean supply container.

5. The pipe lining system of claim **4**, wherein the dry component subterranean supply container is connected to the mixer.

6. The pipe lining system of claim **1**, wherein the dry component subterranean mobile container removably connects to the dry component subterranean supply container at the unloading location.

7. The pipe lining system of claim **2**, further comprising a wet mix conveyor downstream from the mixer.

8. The pipe lining system of claim **7**, further comprising a belt conveyor downstream from the wet mix conveyor.

9. The pipe lining system of claim **8**, wherein each of the mixer, the wet mix conveyor, the belt conveyor, and the mixture applicator includes wheels.

10. The pipe lining system of claim **2**, wherein each of the supply container conveyor assembly and the mobile container conveyor assembly includes a screw conveyor.

11. The pipe lining system of claim **2**, wherein the surface container conveyor assembly includes a generally vertical conveyance section.

12. The pipe lining system of claim **1**, wherein the surface container conveyor assembly includes a screw conveyor.

13. The pipe lining system of claim 1, wherein the dry component subterranean mobile container includes a screw conveyor assembly that is connected to and moves with the dry component subterranean mobile container between the loading location and the unloading location, wherein the screw conveyor assembly delivers the dry component from the dry component subterranean mobile container to the dry component subterranean supply container.

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